RESEARCH Highlight
Basic Energy Sciences Program
Geosciences Subprogram

Title: Micromechanical Processes in Porous Geomaterials

PIs:

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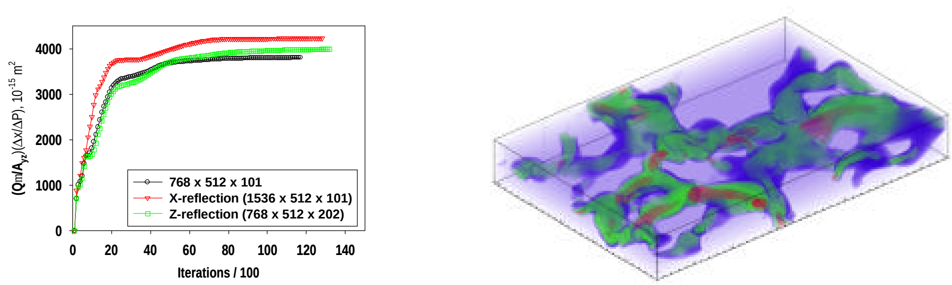
Objective:

The goal of the research program is to enhance fundamental understanding of microscale processes, including failure and transport, in geologic materials and thereby strengthen the scientific basis for the application of laboratory results to technological efforts of current societal concern and impact. The project focuses on systematic investigation of the microscale characteristics of natural earth materials, and how these micro-scale characteristics control the macroscopic deformation and transport behavior.

Results:

In addition to statistical characterization of the geometry of porous earth materials, fundamental understanding of flow processes requires study of the geometry of pore-scale flow itself. The geometry of fluid flow is difficult to ascertain in the laboratory but is amenable to numerical investigation. Fredrich (*Phys. Chem. Earth*, 24, 551-561, 1999) discusses the development of a high-resolution 3D imaging technique that has enabled quantitative characterization of the microscale geometry of porous media at resolutions previously unattainable. This paper describes a process to automatically generate compact numerical meshes from 3D confocal image data. The principal issues regarding the tractable computation of transport phenomena in real porous media lie in the complexity of the geometry and the retention of this structure in the analysis. Lattice Boltzmann methods have arisen as the most attractive approach for simulating flow in complex geometric domains due to the method's unique ability to treat simply and efficiently the multitude of discrete boundary conditions. We achieve the tractable computation of large 3D data sets through development of new storage algorithms to represent complex geometries, in addition to development of a distributed hardware platform. In combination, these advances have dramatically



increased the time and length scales over which transport processes can be simulated using commodity computer components. We describe simulations of single-phase flow in Berea sandstone.

Figure. (Left)) Evolution to steady state permeability during 3D lattice Boltzmann simulation using a reconstructed pore volume for Berea sandstone obtained with laser scanning confocal microscopy. The y-axis is equivalent to the permeability, in units of milliDarcy. (Right) 3D flow visualization from the steady-state solution. Red, green, and blue correspond to the highest, intermediate, and lowest velocities, respectively.

Significance:

This paper describes development and application of a coupled experimental-numerical simulation framework for understanding complex three-dimensional flows in porous geomaterials.

Publication:

O'Connor, R.M., and Fredrich, J.T., "Microscale flow modeling in geologic materials," *Phys. Chem. Earth*, 24, 611-616, 1999.